Why study the water and energy cycle?...

Variations in greenhouse gases, aerosols, and solar activity force changes in climate...

...but, <u>consequences</u> of climate change are realized through the water cycle.



Thus, we must <u>characterize</u>, <u>understand</u>, and <u>predict</u> variations in the global water cycle.

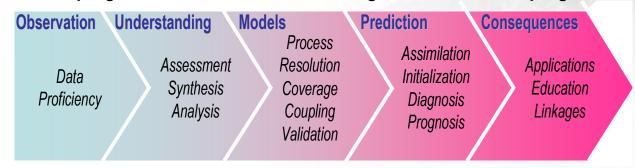
Water and Energy is linked to all 12 Science Application Themes.



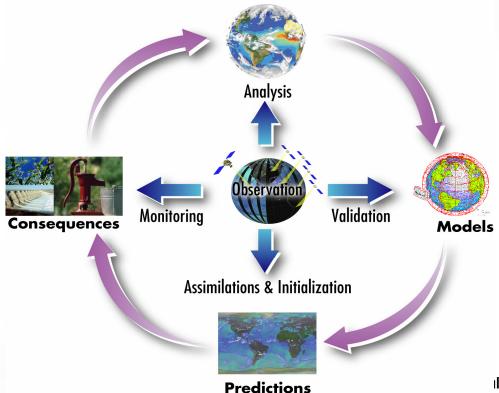
NEWS Integrated Water and Energy Cycle Research

From Observations to Consequences

The NEWS challenge is **global** in scale and requires the integration of NASA **system components** to **make decisive progress toward the NEWS challenge** in an **end-to-end program**



Understanding



NASA Applications Program Approach

Solutions: Science to Decision Support



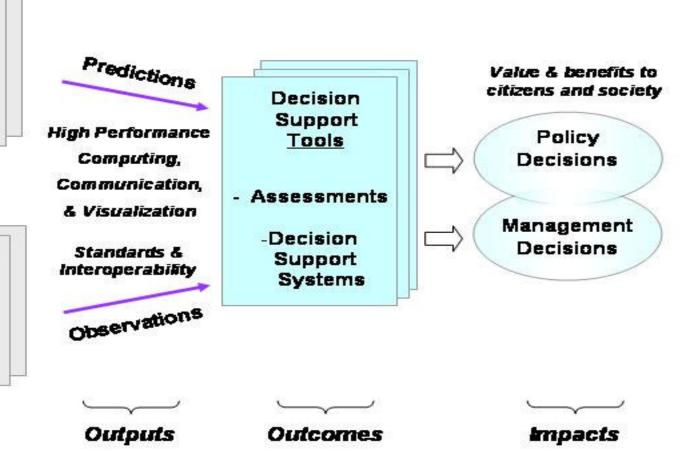
- Oceans Ice
- Land Coupled
- Atmosphere



Monitoring & Measurements

- Satellite
- Airborne
- in situ

Inputs



Strategy 1: NASA Water Management Strategy







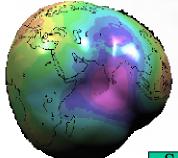












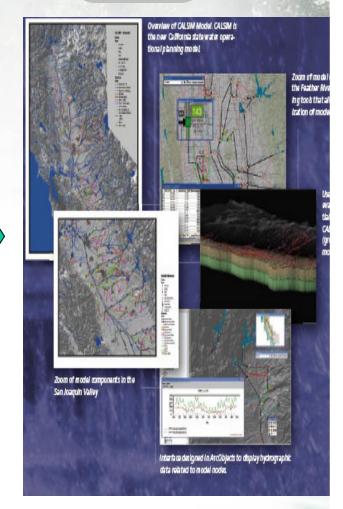
Societal Benefits



EOSDIS & DAACs



Data Assimilation & Modeling



Riverware & AWARDS

Strategy 2: Integrated Systems Solutions

Develop the required integration between research products and end-user solutions using a modeling and analysis system:

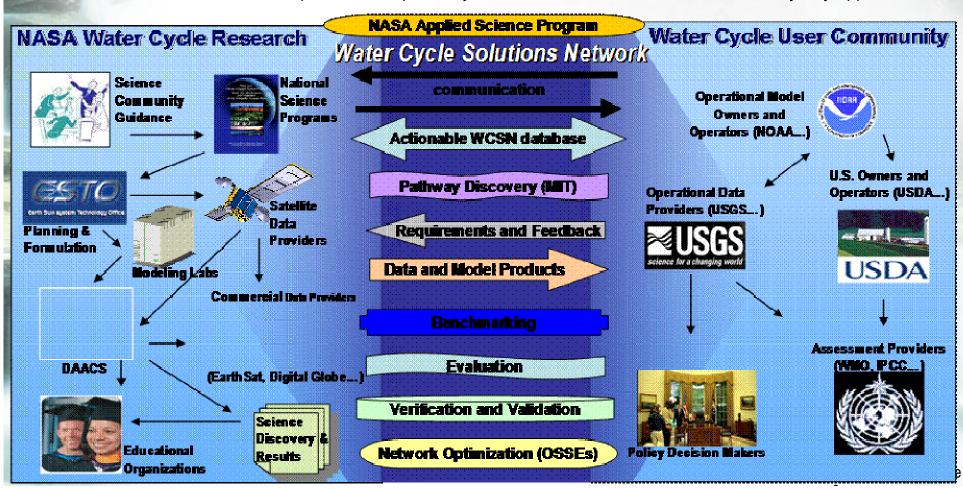
- (a) Customize, develop and test modeling & analysis tools for use in specific DST solutions
- (b) Demonstrate prototype solution in partnership with end-user: manage data, generate runs, make data available to users
- (c) Maintain software, data, and visualization tools up-to-date, and answer user inquiries
- (d) Analysis, optimization, benchmarking, evaluation and verification, of prototype solution
- (e) Document, communicate, and disseminate.

NASA & Partner Research DST Partnership Opportunities Value & Benefit **NASA & Partner Community Models** Policy Decisions: Flood and disease warning; Agricultural Atmospheric Forcing: GMAO, GDAS, **Observations & Predictions Example Partner Agency DSTs** production & efficiency: Aircraft & NCEP, NCAR, ECMWF, AGRMET Forcing: Radiation & Clouds, Agricultural Efficiency: USDA: NIDIS Land: LIS (CLM, VIC, Noah, SSiB, travel safety; Weather warnings; Water Vapor, Precipitation. Air Quality: USEPA: CMAQ Ecological diversity; Optimized HySSiB, Mosaic, CLSM, etc.), SAC Temperature, Winds, etc. Aviation: NOAA NCEP: Eta & WRF energy production; Drinking water Coupled: GMAO, WRF, GCE, ESMF **Parameters:** Topography. Carbon Management: GEWEX CEOP protection; Water use efficiency Vegetation & Soil Properties Coastal Management: USACE: CWMS Management Decisions: **Observation Methods & Platforms** States: Snow Cover & Depth, **Disaster Management:** RMS RiskLink Energy & agricultural production; Ecological Forecasting: USDA: AGWA Soil & Vegetation Moisture. Satellite: EOS Terra & Agua, SSMI. Land use allocation; Aircraft Water Levels, Water Energy Management: USBR: RiverWare SRTM. NPP. Landsat. ICESaT. scheduling; Weather avoidance; Homeland Security: Army: ARMS Availability, Aguifer States GRACE, TRMM & GPM, CloudSAT, Climate change mitigation; Fluxes: Radiation, Carbon, Invasive Species: USBR: AWARDS GOES, NPOESS, HYDROS, etc. Disaster response; Community Evaporation, Transpiration, **Public Health: USEPA: BASINS** Sub-orbital: MW, Vis/IR, Lidar, UAVs planning; Insurance issues Precipitation, Runoff, etc. Water Management: NOAA: NWSRFS In-situ: Meso- and micronets, Surfrad, **Exploration Decisions:** Storm ARM, GTS, field campaigns, etc. prediction; Search for water & life; Resource assessment. **National Academy of Sciences & National Leadership Reviews** INPUTS **IMPACTS OUTPUTS OUTCOMES**

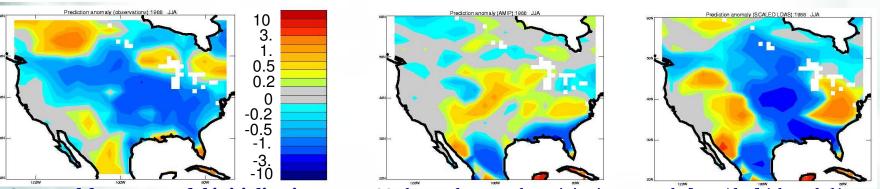
Strategy 3: Solution Networks

"A Water Cycle Solutions Network" was approved by NASA on June 3, 2005, to establish pathways and partnerships between NASA's water cycle research investments and decision support needs.

- 1. Evolve a network of partners: identify and analyze partner organizations to define collaboration pathways.
- 2. Routinely identify, prioritize, mine and communicate relevant research products and results.
- 3. Optimize water cycle partner access to research results and products to create a self-sustaining network.
- 4. Analyze and document the network effectiveness through metrics, resource estimates and documentation.
- 5. Education and outreach is important to help society understand and use the research in every-day application.



Case 1: Land observations leading to improved climate prediction (M. Rodell) **TRMM & IR total** Geostationary satellite daily precipitation [mm] mean downward SW radiation [W/m2]MODIS derived leaf area index MODIS snow cover [%]. ...RESULTS IN IMPROVED MODEL SIMULATIONS... **Model assimilation:** |GOES-INDEX| - |GOES-AVHRR| -- Avg Sfc Temp -- July 2001 LIS/LDAS snow water equivalent [mm] without (far left top) and with (far left bottom) assimilated MODIS snow cover; IMS snow cover "truth" (near left), 20 Jan 2003. Improvement in modeled surface temperature [C] when MODIS leaf area index is incorporated into the land surface model (right). ...AND LEADS TO MORE ACCURATE PREDICTIONS. 0.5 0.2



Seasonal forecast model initialization: JJA 1988 observed seasonal precipitation anomaly [mm/day] (above left);
NSIPP model prediction without (above center) and with (above right) LDAS initial soil moisture | Roster et al., 2003|

Possible application benefits from implementation of NEWS.

WEATHER &	
SAJMATEE m Weather Prediction	• Establish warning system for extreme event forecasting, floods and hurricanes.
Seasonal to Interannual Changes	• Ilmprovesho Altensis ere tersas des Décisiper Stupe ort Systems.
to water cycle	 flora and fauna distributions, energy planning.
Anthropogenic Impacts	Assess Anthropogenic impacts to water and energy cycle.
BIOGEOCHEMISTR	
<u>Karbon</u> Cycle	Study and develop links with water and energy cycle.
Other Nutrients (e.g., nitrogen)	Link water availability with nutrients for air and water quality.
HUMAN IMPACTS	
Water Quality	• Improved water science/availability for assessments (e.g.,
Infectious disease	• Fcethandertions Jinker (fyetas). dry) using remote sensing. Paul R. Houser, 12 September 2005. P

Application benefits from implementation of NEWS (Cont'd).

ECOSYSTEMS	
Coastal Areas	Assess changes to coastal areas from water cycle, sea level
Sea Level Rise	• and wed asdimlates of glaciers and ice sheets. • Study water budget, continental and ocean mass.
Agriculture	Improve assessment and prediction of food production and
Flora and Fauna Distributions	• Wistigration energy eystetchanges critical future changes to
WATER	flora and fauna distributions
AK&I JARI LITY	Provide local to global estimates for closing water budget.
Snow and Ice	• hinkréogenistribution of energyptiezotethallobal pegtinglop techniques for snow water equivalent
Ground Water	mapping estimates via GRACE and indirect estimates via
Surface Runoff	• Ovadplingaាមចំបានបង្ហានទៅគេប៉ាឡាauged basins.
	Indirect (distributed modeling & direct (remote)
Soil Moisture	sehajng)ve from experimental to operational

estimates.

Summary

End-user decision support & solution network connections (NEWS Consequences):

- Understand and document end-user requirements.
- Develop database of NEWS data/model capabilities.
- Develop pathways to connect DST's to NASA WEC capabilities.
- Develop links to the Water Cycle Solutions Network (WCSN)
- •Customize NEWS products of develop new products that are responsive to WCSN identified end user needs.
- The NEWS consequences component is not well established
- Consequence of NEWS being a science program
- •Must establish strong links with the applied sciences components of NASA.